Equilibrium Model answers.

Physical Equilibrium

Consider a glass of water left on a bench, over a period of time the water will evaporate.

Write an equation for this process

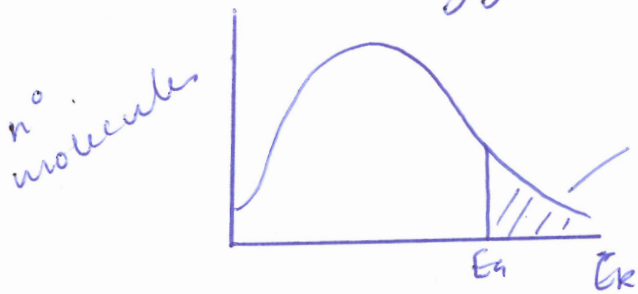
$H_2O(l) \rightarrow H_2O(g)$.

Why does this happen?

A small number of high energy molecules at the surface of the liquid have sufficient energy to overcome the attractive forces between water molecules.

Can you explain this using the concept of "Activation Energy" ?

The energy required to overcome the attractive forces when water (the energy required for a molecule of water become vaporised) can be thought of as an "activation energy.



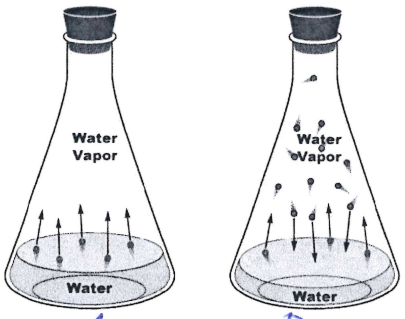
Because the more "energetic" molecules escape, this lowers the average Ek of the remaining molecules. *

If you put a lid on it how does this change things and why?

It prevents high energy molecules escaping. As the concentration of $H_2O(g)$ increases, the chance of them colliding and returning to liquid increases. If temperature is kept constant the rates of evaporation and condensation will become equal.

*This is why the temperature of a liquid falls as evaporation takes place. Heat flows in from the surroundings, the Ek(average) increases again and the energy distribution "spreads out". Now other molecules will gain E > Ea and the cycle continues until the liquid evaporates to dryness.

The following diagram represents the creation of a dynamic equilibrium. Explain what us happening in each flask.



A. B.

A: high energy water molecules at the surface of the liquid are able to evaporate and enter a gaseous state.

B: $H_2O(l) \rightleftharpoons H_2O(g)$

B. As the concentration of gaseous water increases, collisions occur that result in liquid water being produced (condensation) and the rates of these two process become equal.

Use this to devise a definition for "equilibrium"

a physical or chemical process that is reversable, where the rates of the forward and reverse processes are equal and the concentration of all species remains constant.

Describe what you would observe in flask B if the temperature was increased. Explain what effect this has on the equilibrium.

The volume of liquid water would decrease. When heated more of the water molecules on the surface would have sufficient energy to become gaseous, so the evaporation rate increases. As the gaseous concentration increases, so will the rate of condensation. Eventually equilibrium is established where the rates of both processes are equal (and higher) and the concentration of gaseous water is higher relative to the volume of liquid water.

Another physical scenario

In a saturated solution of sugar in water, excess solute in contact with the saturated solution dissolves at the same rate as it crystallises.

$C_{12}H_{22}O_{11}(s) \leftrightarrow C_{12}H_{22}O_{11}(aq)$

Describe what would happen to this equilibrium system if the temperature was decreased?

The average kinetic energy would decrease. Less aqueous sugar molecules would have energy to overcome forces of attraction from other sugar molecules. This would lead to an increase in the mass of solid and a decrease in the number of aqueous molecules. The rate of dissolution would decrease initially whilst the rate of crystallisation would stay the same. Eventually both rates would become equal but lower.